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JULY, 1903.

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NOTICES OF The Aëronautical Society.

At a meeting of the Council of the Aëronautical Society of Great Britain held at the Stanhoe Hotel, Worthing (the headquarters of the Society during the International Kite Competition held at Findon), on June 24th, 1903, the following gentlemen were elected members of the Society:—

CAPTAIN JOHN BOSTROEM,
Naval Attaché to the Imperial Russian Embassy.

CHARLES WILLIAM BECKMANN.

COLONEL J. E. CAPPER.

MR. S. F. CODY.

MR. WILLIAM GREEN.

THE ST. LOUIS AIRSHIP CONTESTS.

A communication has been received by the Council of the Aëronautical Society of Great Britain from Mr. Octave Chanute, M. Aër. Soc., and Honorary Commissioner for the St. Louis Exposition, in which the suggestions of the Aëronautical Society of Great Britain are invited concerning the published rules of the aëronautical contests to be held in connection with the St. Louis Exposition in 1904.

The Council of the Aëronautical Society of Great Britain have decided to hold a council meeting to consider Mr. Octave Chanute's communication. Meanwhile, any member of the Aëronautical Society who has any suggestion to make is requested to forward same to the Honorary Secretary of the Aëronautical Society of Great Britain, 53, Victoria Street, Westminster, London, S.W., as soon as possible.

The rules will be found in the October (1902) number of the Aëronautical Journal.

In answer to enquiries, the Hon. Secretary begs to state that the newly-formed Aëronautical Institute and Club is in no way connected with the Aëronautical Society of Great Britain.

ERIC STUART BRUCE,
Honorary Secretary.

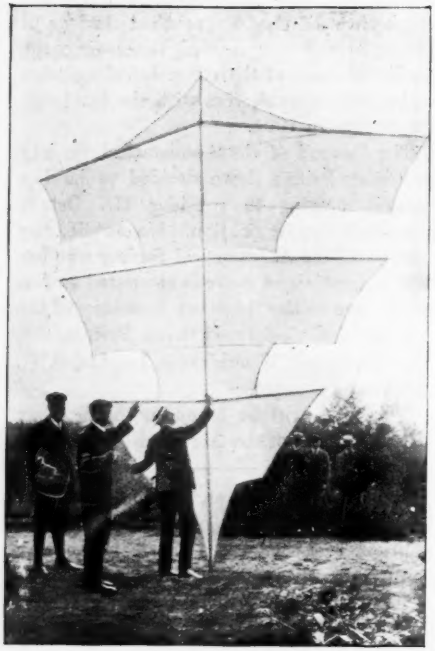
GENERAL MEETING.

The concluding meeting of the thirty-eighth session of the Aëronautical Society of Great Britain was held on the Sussex Downs, near Findon, by kind permission of Lord Henry Thynne, on Thursday, June 25th, 1904, at 2.30 p.m., to witness the International Kite Competition for the silver medal of the Society.

The proceedings of this meeting commenced on the evening of Wednesday, June

24th, when the Council of the Aëronautical Society of Great Britain and the Jury of the Competition and several members of the Society met at the Stanhoe Hotel, Worthing, which was the headquarters of the Society on the occasion of their visit. The Council and the Jury dined together, and later in the evening there were meetings both of the Council and of the Jury.

Early next morning a special brake conveyed Council, Jury, and Engineers to the scene of the first International Kite Competition that has been held. Here there was erected a spacious marquee for the convenience of members of the Society, in which



Mr. Charles Brogden's Kite.

refreshments could be obtained, and where there was an exhibition of objects of aëronautical interest.

This spot was selected for the aërial contest after months of search for the fittest place. In view of the extraordinary interest which has been aroused in kite flying by the efforts of the Aëronautical Society of Great Britain, it is as well to point out that, in the opinion of the Council of the Society, kite competitions in the neighbourhood of large cities might become a source of danger to life and property. They should take place in isolated spots, as far as possible from roads and railways.

At the International Kite Competition there were over one thousand persons present, amongst them being the representatives of the Russian, Austro-Hungarian, and German Governments. The full report of the proceedings is reserved for the opening meeting of the new session, when it will be read to the members of the Society, and subsequently published in the January number of this JOURNAL. It will now suffice to reprint from the programme certain details of the arrangements, and of the exhibition, and to announce the result.

The competition was for the highest flight attained by a single kite above 3,000 feet.

COMPETITORS.

MAJOR B. BADEN-POWELL, Scots Guards.
President Aëronautical Society.
Mr. E. ERNEST BARCLAY.
Mr. CHARLES BROGDEN.
Mr. ALAN BURGOYNE
Mr. S. F. CODY.
Mr. L. CODY.
Mr. BERNARD D. LANG.
Mr. S. H. R. SALMON.

JURY.

Dr. NAPIER SHAW, F.R.S.
(*Chairman of Jury*).
Professor C. V. BOYS, F.R.S.
Mr. E. P. FROST, J.P., D.L.
Sir HIRAM MAXIM.
Dr. HUGH ROBERT MILL, LL.D., F.R.G.S.
Mr. E. A. REEVES, F.R.G.S.
Mr. ERIC STUART BRUCE, M.A. Oxon, F.R. Met. Soc.

ENGINEERS.

Mr. J. E. DALLAS, Mr. N. F. MACKENZIE, } *Royal Engineering College, Cooper's Hill.*

The COMPUTER.

Mr. W. MASON,
Demonstrator, Engineering Laboratory, King's College, London.

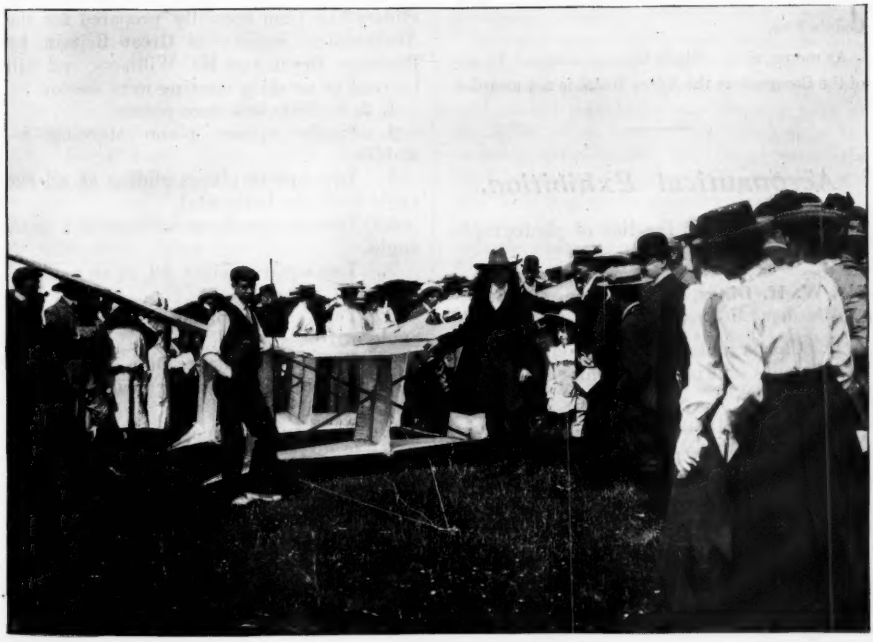
STEWARD.

Colonel F. C. TROLLOPE,
Late Grenadier Guards.

Two competitors, Mr. Alan Burgoyne and Mr. B. D. Lang, were obliged to withdraw at the last moment owing to accidents having occurred to their respective kites

INTERNATIONAL KITE COMPETITION.

Mr. S. F. Cody adjusting his Kite.



Mr. L. Cody's White Kite.

during rehearsal. Six competitors started their kites, and the first series of observations taken by means of the theodolites were of all six. Two competitors, however, fell out, and the observations were continued for the rest of the time on the remaining four.

The result, which will be more fully dealt with in the report, was as follows:—

THE MEAN OF THE OBSERVATIONS FOR ALTITUDE.

	Feet.
Kite No. 6 (Mr. Charles Brogden)	1,554
Kite No. 7 (Mr. S. F. Cody)	1,326
Kite No. 3 (Mr. L. Cody)	1,271
Kite No. 2 (Mr. S. H. R. Salmon)	1,189

THE ACTUAL GREATEST HEIGHT OBSERVED FOR THE KITES.

	Feet.
Kite No. 6	1,816
Kite No. 7	1,407
Kite No. 3	1,476
Kite No. 2	1,339

It will be seen that Mr. Charles Brogden's Six Winged Kite, of which an illustration is given, is first, both in the mean of observations and for actual highest flight observed. Mr. L. Cody's Kite has the second place for highest flight observed, though in the mean of observations he takes the third place, the average of heights in his case not being so well maintained as in the case of Mr. S. F. Cody's Kite.

As the required altitude was not attained by any of the Competitors the Silver Medal is not awarded.

Aëronautical Exhibition.

The following is the list of photographs and objects exhibited.

Mr. W. H. Dines, M. Aer. Soc. *(President of the Royal Meteorological Society, 1901-2:*

1. Charts obtained from self-recording instruments sent up by attachment to a kite at Crinan, N.B.

July 15. Maximum height 6,250 feet.

Aug. 12. Very light wind. The Chart is interesting, as showing the very dry air found at a few hundred feet elevation.

Aug. 23. Maximum height 11,850 feet.

2. Set of six photographs relating to observations obtained in Crinan.

3. Plan of making eye at end of wire, and also plan of joining two wires. The steel wire is passed through the brass tube and the end hooked over before the latter is bent. The steel wire is not softened.

4. Clamp for attaching supplementary kite to line.

The wire is placed between the two rings at the end of the clamp, it is then turned spirally some ten times round the tail of the clamp, and the line from the supplementary kite is secured to the rings.

Professor G. H. Bryan, M. Aër. Soc., F.R.S., and Mr. W. E. Williams:

Photographs of the paths of aërial gliders.

These photographs were taken by attaching magnesium wire to small gliders, consisting of square planes and pairs of square planes, and allowing them to descend in front of a camera in a dark room with the wire burning. By placing a rotating wheel in front of the camera, a dotted instead of a continuous track was obtained, enabling the velocities at different points to be compared. When the path is nearly straight two sets of oscillations are observed. If either of these oscillations increases as the glider descends, the glider will be longitudinally unstable. A mathematical investigation of the longitudinal stability of gliders has been specially prepared for the Aëronautical Society of Great Britain by Professor Bryan and Mr. Williams, and will be read at an early meeting next session.

1. 2. 3. Single square planes.

4. Single square plane showing instability.

5. Two square planes gliding at a large angle with the horizontal.

6. Two square planes inclined at a small angle.

7. Two square planes set at an angle of 15°.

8. Two square planes inclined at an angle of 10°.

9. Two square planes at a small angle showing instability due to increase of oscillation of small period.

10. Two square planes at a small angle.

The Rev. J. M. Bacon, M. Aër. Soc.:

1. Two pictures, each giving a series of snapshot photos. illustrating the inflation and ascent of the Maskelyne-Bacon hot-air balloon.

2. View of the sea-bottom in 10 fathoms of troubled water, photographed from a

balloon at a height of 600 feet over the Irish Sea.

3. Four views of land, sea and cloud, taken during the above voyage.

4. Three views of city and cloudscape taken over London.

Aëronautical Society of Great Britain:

1. Illustrations from the Aëronautical Journal published by the Council of the Aëronautical Society of Great Britain.

2. Prints of Aëronautical Celebrities:

(1) The late Mr. James Glaisher.

(2) The late Mr. Percy Pilcher.

(3) Monsieur Janssen, Director of the Observatory of Physical Astronomy at Meudon, Paris.

3. Plaster Casts of The Sparrow Balloon Coins, presented by the keeper of the Coin Department, British Museum.

The balloon ascent recorded by these coins was made on June 13th, 1823, from the Oxford Gas Works, in commemoration week, by Mr. Isaac Earlyman Sparrow, an enterprising ironmonger, who advertised by coins or tokens, accompanied by Mr. Green, the famous aëronaut, to whom the balloon belonged. The three representations of the balloons in the coins would seem in each case to be from the pen of different draughtsmen. (See *Aëronautical Journal*, October, 1901.)

4. Photographs of the Anderson Kite Equipment of the Scottish National Antarctic Expedition.

1. Winding gear. 2. Box kite.

Eric Stuart Bruce, Esq., M.A., Oxon, F.R. Met. Soc.:

1. Charts of the wind forces taken near the summit of the Eiffel Tower, Paris (305m.), during M. Santos Dumont's experiments with his navigable balloons in 1901, Figure 9, showing that a wind force of 5 metres a second was overcome by the experiment.

2. Post card illustrations of the Vincennes Balloon Competitions, presented to the exhibitor by M. Jacques Faure, the late Treasurer of the Paris Aëro-Club.

Mr. A. South, M. Aër. Soc.:

Two models of the South and Groombridge propellors for aërial purposes.

Mr. William Cochrane, M. Aer. Soc.:

Working model of mechanical bird, fitted with oscillating feathering propellers and new horizontal tail stearing gear.

Mr. S. F. Cody: Photos of Man-lifting Kite

* * *

The Wind Forces overcome in the Experiments of M. Santos Dumont with his Navigable Balloon in Paris 1901.

By a Member of the Paris Aëro Club.

As will have been seen above, in the recent aëronautical exhibition held on the occasion of the International Kite Competition, there was exhibited a map of the wind forces overcome by M. Santos Dumont during his experiments with his navigable balloon in Paris, 1901. As the main point at issue in a navigable balloon journey is the wind force actually overcome, and as it is a question which in the published accounts of M. Santos Dumont's experiments has been begged, notwithstanding its importance, it may be acceptable to the readers of this journal to offer some explanation as to the connection of the charts here reproduced with M. Santos Dumont's journeys.

The first chart (Fig 1) representing the wind force at the summit of the Eiffel Tower (305 metres) during the experiment of July 12th, 1901, shows that there was absolute calm at the Eiffel Tower during from 3 o'clock in the morning until nearly 10. Here were the ideal conditions for a navigable balloon, and they were used to the greatest advantage. On this day M. Santos Dumont made thirteen voyages, ten round Longchamps, one to Puteaux, one to the Eiffel Tower, and another to St. Cloud. In one day he, therefore, beat the previous record of the voyages made in a navigable balloon, and showed his mastery of the vertical motion of the balloon in a calm atmosphere by keeping at an altitude not exceeding 270 metres for a total distance of 45 kilometres.

On the thirteenth of July M. Santos Dumont made his first attempt to win the Deutsch Prize, which was open to any aëronaut who should steer a balloon from the grounds of the Aëro-Club round the Eiffel Tower and back in half-an-hour. On the day mentioned he failed to accomplish this feat by ten minutes. In the French account of the journey it is stated

CHARTS.

Vitesse moyenne du vent en mètres par seconde au Sommet de la Tour Eiffel (305 mètres au-dessus du sol). Direction du vent au Bureau Central Météorologique (18m au-dessus du sol) et à la Tour Eiffel observées aux heures indiquées.

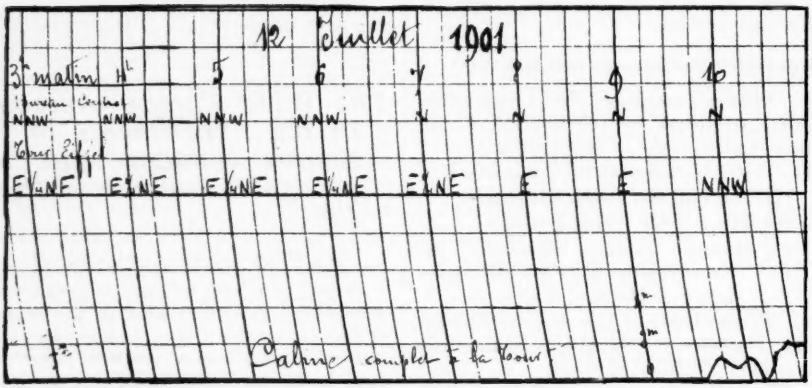
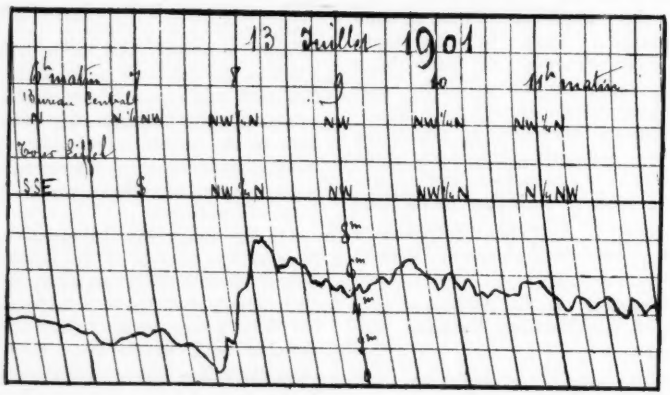


FIG. 1.



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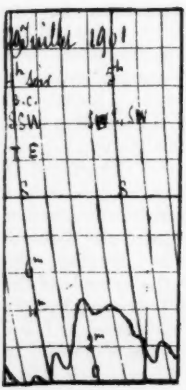


FIG. 3.

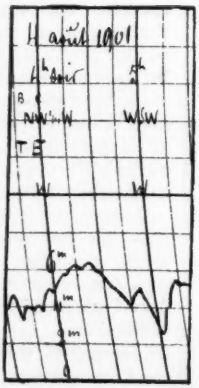


FIG. 4.

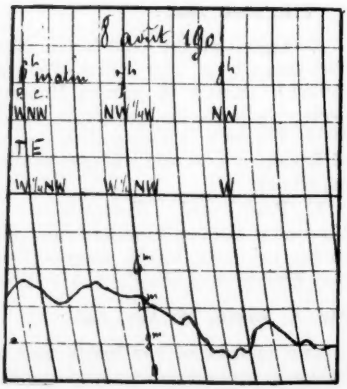


FIG. 5.

CHARTS.

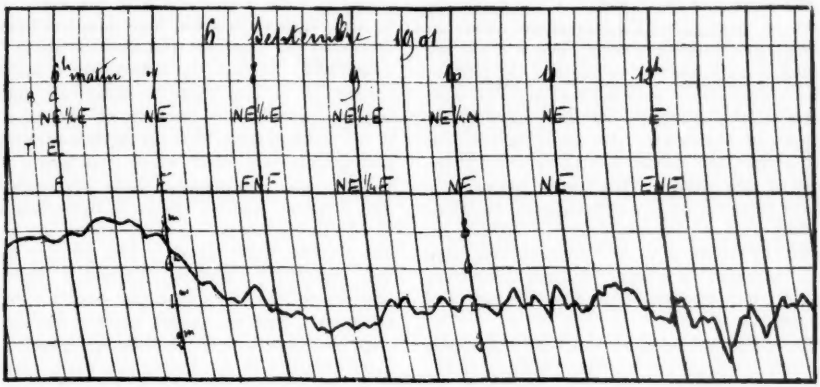


FIG. 6.

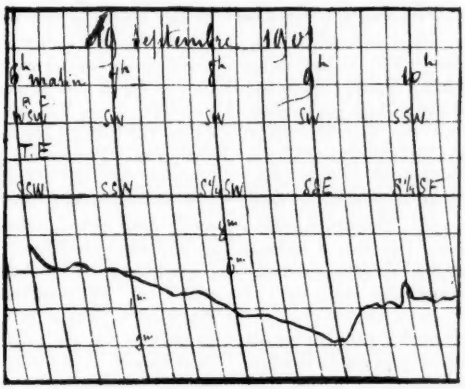


FIG. 7.

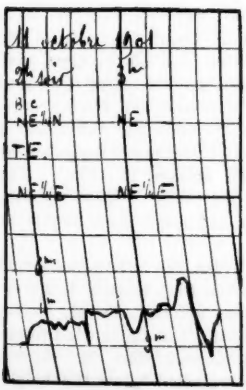


FIG. 8.

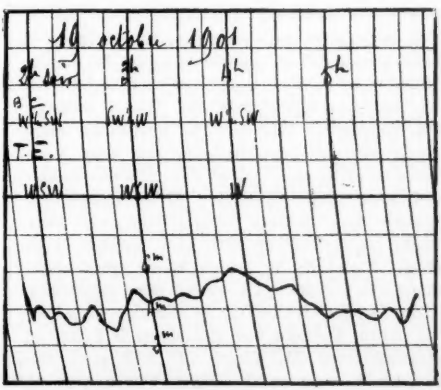


FIG. 9.

that for ten minutes of his return journey with his motor running down, M. Santos Dumont went against the wind, and the force of the wind had redoubled. A glance at the chart of that date (Fig. 2) shows that the balloon, in returning, went against a wind, but a wind of only one to two metres, the journey being accomplished between 6.41 and 7.21 a.m. The time of this journey was prolonged by the collapse of the motor. In the reports it was stated that the motor was enfeebled by the force of the wind. This was, however, a fallacy, as the wind force throughout the whole of that experiment was next to nothing, as shown by chart 2. At 8 o'clock the wind force increased, it is true, to eight metres per second, but by that time the journey had terminated.

The journey of August 8th was remarkable for the accident due to the collapse of the ballonet apparatus, which precipitated M. Santos Dumont on to the roof of the Trocadero Hotel, and not on account of any high wind force. It is claimed that on this journey the record of speed, viz., five kilometres 500 m., was accomplished in 9.m. 7″, on going with the wind to the Eiffel Tower, the wind force being from four to five metres per second. It was thought that on this day he would accomplish the journey round the Tower in less than the required time, though, in returning, the wind was against him at a rate of from four to five metres a second. But the accident which shattered in pieces the No. 5 balloon put an end to what might have been a more brilliant performance than the final one of October 19th.

The chart of September 6th (Fig. 6) shows the wind forces on the first journey of the No. 6 balloon, in the construction of which new details of interest were added, such as the employment of liquid ballast. The motive power was increased to 20-horse power, but it will be seen by the charts that the increase of horse power did not appear to tempt M. Santos Dumont to combat a greater wind force than he had previously with his No. 5 balloon. On September 6th various evolutions were made with his new balloon, but they were terminated by an accident owing to the rudder not being well adjusted. Other excursions, though not definite return journeys, were made on September 19th and October 11th (Figs. 7 and 8), in which winds from seven metres to two metres a second were registered.

On October 19th (Fig. 9), the day on which M. Santos Dumont won the Deutsch Prize, at starting from St. Cloud at 2.42 p.m. the registered wind at the Eiffel Tower was 4½ metres a second. As he approached the Tower it amounted to five metres a second, but when he arrived it had abated somewhat. The journey to the Tower was with the wind, and he arrived there in about nine minutes, having traversed an apparent distance of about 5½ kilometres; though, in calculating a balloon course, it is impossible to state the actual length traversed on account of the veering of the balloon from local air disturbances until instruments are used which can locate the balloon and compensate these divergencies. The dirigable balloon seems to have doubled the Tower at about the level where the wind observations were taken. The journey back was apparently executed against a wind of rather less than five metres per second. Being against the wind the return journey was slower than the journey out, the balloon appearing to have difficulty in combating the wind, veering and swaying heavily. It was noted that in rounding the Tower the balloon veered considerably. This fact may be ascribed in part to the length of the balloon, for, with extension of the axis of the balloon and of the wind, a larger surface is exposed to the wind, and this is one of the dangers of the elongation of balloons. At 11 minutes 30 seconds after 3 p.m. the balloon arrived above the Aëro-Club enclosure. The actual journey had taken 29½ minutes, but the balloon was high in the air, and by the time it had been lowered and the guide rope seized, according to the conditions of the Deutsch Prize, the time had been exceeded by a few seconds. The guide rope was seized at 12 minutes 40 seconds past 3. Everyone is aware of the consequent dispute as to whether the prize had been won and its final award to M. Santos Dumont. This last journey appears to be somewhat typical of the wind forces that have been overcome in the Santos Dumont journeys. The dirigable balloon appears on this occasion to have rounded the Tower at about the level of the observatory, where the wind observations were taken. The progress in overcoming the wind seems, therefore, to consist in having overcome a wind force of about one metre and a half per second greater than that overcome by Captains Krebs and Renard in 1885. The latter, however, had only 9-horse power, whereas the former had more than double at his disposal.

The height at which the above-mentioned wind forces were taken (305 metres) fairly represents the altitudes attained by M. Santos Dumont; but in quoting the above wind forces it must be remembered that M. Santos Dumont sometimes travelled below the height

of 305 metres, therefore, the wind force at the precise level at which he travelled may not in reality have always quite reached the figures above quoted. It is clear that the only reliable figures would be those taken on board the airship. Here arises a difficulty. It is not an easy matter to locate a dirigable balloon or a free balloon of any sort, and on such a location all calculations would have to rest. M. Santos Dumont and his partisans are of opinion that such a location is an impossibility. They consider that the length of time of a balloon journey and the number of miles known from place to place would be no measure of the actual course traversed, owing to the fact that such a body is rarely still and in one place. It is affected by vertical currents of air, by movements in the horizontal layers of the atmosphere, by movements set up by the action of its own rudder and its own screw, and its consequent oscillations render unprecise the appearance of the panorama beneath, upon which measurements might be based.

On somewhat the same grounds M. Santos Dumont and his partisans appear to have no faith on the calculations of his own speed deduced from the reading of an anemometer on board. On July 12th, on a very calm day, he took up an anemometer to see what it would register, and it showed 40 kilometres an hour, a reading in which he had no confidence. He considers that the non-comparable inertia between the balloon and the vanes of an anemometer, affected by the various currents alluded to above, would alone falsify results, and they extol the commission for having not made a wind velocity a condition of the prize. But there is a school of French aëronauts who maintain that M. Santos Dumont and his colleagues are in error in such statements, and that with the instruments now at our command, a balloon could be located, that the error arising for the veering could be compensated, and that various exact measurements could be deduced.

If the actual advance to aërial navigation in M. Santos Dumont's experiments is small, the picturesque nature of the manner of doing and the very great personal qualities the attempt called forth in the doer, have had a moral effect far in excess of what was warranted by the mere quantitative index of progress. M. Santos Dumont himself ascribes the new period of activity in aëronautics to the evolution of the petroleum motor through the autocar. But he, perhaps, modestly forgets the power of individualism and the impetus to experiment that his own persistence has accumulated.

Experiments relative to Equilibrium and Angle of Fall in Gliding Flight.

By Major L. S. Blackden.

Recent experiments have led me in two directions—both a good deal governed by considerations of construction, which, in any case, is always poor.

In one direction I improved the steadiness of flight, but was very dissatisfied with the angle of fall; in the other direction I improved, by diminishing, the angle of fall, but was extremely dissatisfied with the steadiness of flight.

In trying different wing profiles—such as could be easily made by bending a piece of thin cardboard, I found the steadiest forms were those that required the centre of gravity to be furthest forward, but they did not give good angles, while the best angles were given by shapes which, wherever the centre of gravity was, would always pitch forward unless controlled by a large and well turned up tail.

It appeared probable that in the steady form with the bad angle all the lift came from a limited part of the wing near the forward edge, while the bulk of the after part of the surface acted more or less as a steadying rudder or tail. Figs. 1 and 2 give a steady and inefficient, and an efficient but unstable section respectively.

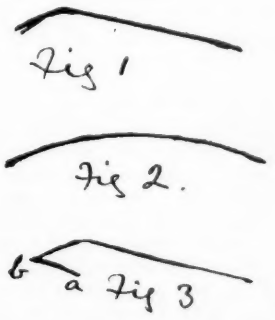


Fig. 3 shows a section, which glided steadily with no tail or guiding surface at all. In this section I supposed that probably all the lift came from the back-turned part, a-b, and that the whole after part acted as a tail or rudder. Its angle of fall was barely one in one.

I then turned my attention to the tail, which must be turned up in order to prevent any curved surface from pitching over forward, and tried various shapes.

I found breadth of spread of more importance than length from front to rear in securing steadiness, and the best fore and aft section was one the anterior half of which was flat, whilst the posterior half was curved. Vide Fig. 4.

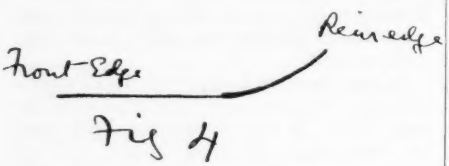


Fig 4

Here, again, the tail that gave the steadiest flights gave the worst angle of fall—the upturned end acted, probably, more or less as a drag.

When experimenting with tails I found that a big tail, well turned up, would always give steady flight, though the angle of fall might not be good. It also allowed of a wide range of position for the centre of gravity in a fore and aft direction. A glider so made, with the centre of gravity about one-third of the wing-breadth from the front edge would glide fairly well. Closer to the front edge it did better but required to be thrown with greater speed.

I then placed the centre of gravity in front of the front edge of the wings. The glider would not glide by its own weight at all, but if thrust vigorously forward would sail across the room almost horizontally and very steadily, but its course began to sink towards the end, and if tried where there was enough space, would finally fall on its head. Evidently a sufficient speed would cause such downward pressure on the tail, and such upward pressure on the wings, that, to balance these pressures, the centre of gravity would have to be in front of the wings. Greater speed did not make it mount upwards, but allowed the glider still to sail horizontally, provided the centre of gravity were placed sufficiently forward.

This experiment suggests that in a motor-propelled machine there should be some arrangement by which the aëronaut, during flight, could alter his position through a considerable distance in a fore and aft direction, in order to allow him to use different speeds—exceeding "soaring speed"—without departing from a horizontal course. The constant connection of steady flight with a bad angle seems to suggest that an increase of safety in dynamic flight depends on increasing the proportion of power to weight in the motor. But for the present, and for some time to come, safety will depend chiefly on the skill of the aëronaut, and the constructional strength of the machine.

In endeavouring to obtain a greater steadying power with less upward angle of the tail, it struck me that I might utilise the downward current of air at the posterior edge of the wing—supposing the air to be deflected downwards in passing the wing, as in Fig. 5.

I, therefore, made a glider with a good lifting section of the wings, namely, a circular curve in the fore and aft direction, while remaining straight transversely—like a slice from the top of a horizontal cylinder—and attached to it a tail, curved like the wings, only with the hollow side upwards, so that the leading edge of the tail was vertically beneath the rear edge of the wings and close to it, as in Fig. 6.

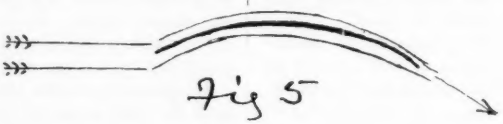


Fig 5

This glider flew steadily with the tail set at a smaller upward angle than I found necessary when I applied the tail with its front edge continuous with the back edge of the wings as in the dotted line in Fig. 6. The improvement of the angle of fall was, unfortunately, not so marked as the reduction in the angle of the tail led me to hope.

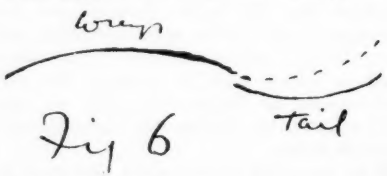


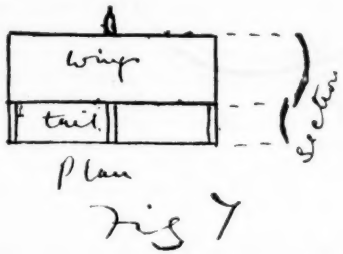
Fig 6

I then made a glider on the same principle, but with the transverse spread of the tail equal to that of the wings, but a good deal shorter from front to rear—being about two-fifths of the width of the wings from front to rear. Vide Fig. 7.

The tail was attached to the wings both at the centre and ends.

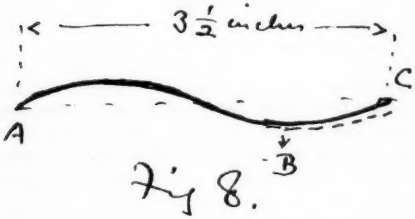
This model glided very steadily and at a very good angle, but it was very light for its surface, spreading, as it did, 31½ square inches of

wing-surface to only about 7-8ths of an ounce weight, or at the rate of about four ounces to the square foot, and I have always found that the lighter a model is, the flatter



is its angle of fall, due to wing edges and framing generally giving less proportionate resistance at lower speeds.

About the same time I tried a new section without a separate tail at at all. This was, as



usual, straight transversely, but curved into an S in the fore and aft direction. Each half was bent to the arc of a circle, having the height of arc equal to a twelfth of the length of chord. The front half had the concavity beneath, the rear half having the converse side downwards as in Fig. 8.

With this section I thought it possible that some lifting effect would be obtained from the anterior three-quarter of the surface, A B in the Fig., and that the posterior quarter, B C in the Fig., would act as a steadying surface, or tail only.

The dimensions were as follows:—

Spread 18 ins. Total width 3½ ins.

Supporting surface = ¾ (3½ × 18) = about 47 sq. ins.

Weight 2 ozs.—or about 6 ozs. to the sq. foot.

This was also steady, and flew at a fair angle —better than I had yet obtained with any glider except that shown in Fig. 7. I added a weight of lead, which brought it up to the proportion of 1 lb. to the square foot, and threw it out of doors. The flight was fairly steady, but with a small and quite slow rocking motion, and it fell at an angle of about one in five. It struck the ground with one wing before the other and broke.

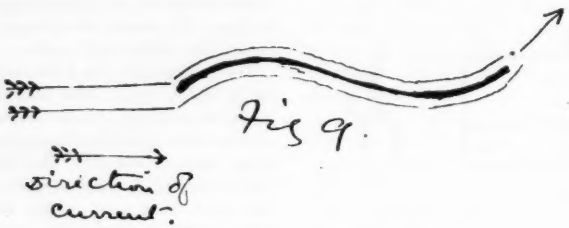
Its good angle—for I find one in five is good for a small, and I fear roughly-made, model, when heavily weighted—probably due to its considerable spread in comparison to width of wing, and its stability, like that of the model shown in Fig. 7, due, in part at least, to the fact that every part of the wing had its own bit of tail to steady it. I have generally found long narrow wings more difficult to balance than short and wide ones, and I think that, in my experiments at least, part of that difficulty was due to the greater flexibility of the long and narrow wing, which allowed a great part of the outer end of the wing to begin to upset before it felt the steadying influence of the tail.

To recapitulate, I had found that, with wings straight transversely, a circular curve in the fore and aft section—"cylindrical" wings in fact—gave a better angle of fall than the other shapes tried, but had a strong tendency to plunge or pitch forward, which was best corrected by a tail extending transversely the whole length of the wings and attached as rigidly at the ends as the centre. It did not require to be as wide—fore and aft—as the wings, nor was it necessary to give it as deep a curvature as the wing, and it seemed to give a rather better angle of fall, and certainly did not require to be turned up so much, when its front edge was just below the back edge of the wings, than when in prolongation of the back edge as in the S-shaped section (which went best when the rear quarter had been flattened a little as in the dotted line in Fig. 8). The best curvature of the tail was found to be flat near the front edge and curved behind. In diminishing the spread of the tail transversely, it had to be increased in length from front to rear, and turned up at a greater angle —which increased the angle of fall owing to its greater drift in proportion to its depressing, or steadying power.

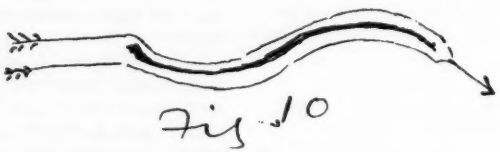
With regard to the theory* that the air, in passing the wing, follows the surface exactly, and, striking the front edge with a relatively horizontal motion, leaves the rear edge with a relatively downward motion, and thus tends to lift the wing, as in Fig. 5—this explanation does not seem to apply to the S section men-

* "Aëronautical Annual," 1896, p. 41.

tioned above, *vide* Fig. 9—and yet this section undoubtedly lifts, and lifts well, and has the advantage of having no tendency to plunge.



If a surface of this form is turned upside down, as in Fig. 10—when, according to the theory mentioned above, it ought to lift, as the air striking horizontally, and following the surface, should leave it with a downward trend—it not only does not lift, but it is certainly pressed forcibly downwards.



(The air currents represented in Figs. 5, 9, and 10, are supposed to follow the surface parallel to it.)

My "cylindrical" wings did not all behave alike. I probably made them badly, and the flexibility may have differed in different models, so that I cannot say what shape they took under pressure. At any rate, I often—but not always—found that they rocked with varying violence from side to side, as I mentioned in my last paper.

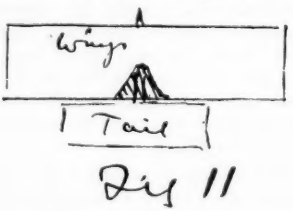
I had one the other day which did nothing but rock. Not only did the wing-tips alternately move up and down, but the whole glider at the same time oscillated from side to side. I made quite sure that, in this model, presenting the wings to the air at a flatter angle did no good at all in preventing this rocking, although it certainly diminished it.

All the gliders that rocked in this way gave the impression that they were "spilling the wind" from under the wings—that is, that compressed air had gathered in the hollow of the wing, and that this air escaped, first at one end of the wing-surface and then at the other. It reminded me of the rocking of a parachute in descent, and strongly suggested the necessity of something to correspond with the hole in the top of a parachute.

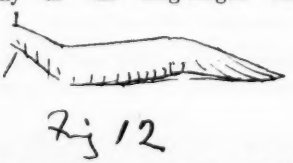
I took the glider that rocked so persistently and cut a wedge or V out of the back edge of the wing-surface in the centre—*vide* Fig. 11—to allow the compressed air, if such there were, to escape.

The result was wonderful. The rocking entirely ceased, and I secured steady glides, both in and out of doors, with that glider as long as the wings retained any approach to symmetry.

This result interested me very much, especially with reference to the shape of the wing in



soaring birds. These birds' wings have a negative angle near the body, and sometimes, especially in the long-winged birds, a



diminished width, as in Professor Pettigrew's figure of the wing of the albatross—which is more or less like that shown in Fig. 12.

Both the negative angle and the diminished width would allow of the escape of compressed air near the body, exactly as the V-shaped cut in my models, and, on the principle of equal and opposite reactions, the escape of air at that point would have the very valuable effect of driving the thickest portion of the wing forward through the air, thus making full use of the downward curve at the front of that portion of the wing.

The fact of the wing-arm, between the elbow and the wrist, always pointing forward, would assist in directing the air towards the back edge of the wing near the body.

I, therefore, made two new models, one having wings shaped like a section of a hori-

Fig 13

zontal cylinder, and the other having wings of the same shape, but cut in two at the centre, and each half attached to the body with a forward inclination, *vide* Figs. 13 and 14.

These two models were the same in weight and area of both wings and tail, but the tail of the second, Fig. 14 (No. 2), did not get the full effect of the down draft from the back edge of the wings as well as in the other, Fig. 13 (No. 1), owing to the forward inclination of the wings.

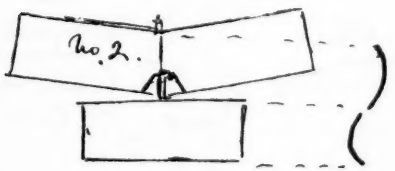


Fig 14

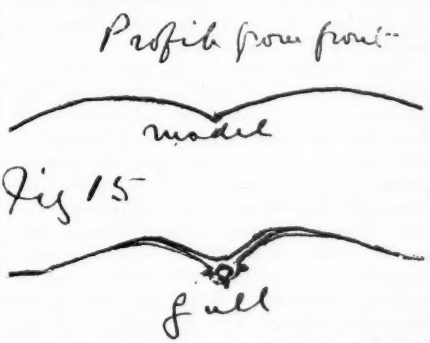
I expected greater steadiness and a better angle with No. 2 than with No. 1—but I didn't get it.

At first No. 2 seemed a little the best, but when I cut a V in the back of the wings of No. 1, it distinctly beat No. 2, both in steadiness and angle of fall.

The explanation lay in the fact that I was letting the air escape too easily, so that less compression took place, and there was not sufficient support.

This model (Fig. 14) did distinctly better when I gave the wings a slight dihedral angle. The air, coming in so easily from the wing ends was given a downward trend by the dihedral angle, and so did a little work. Evidently if the wings were not only curved from front to rear, but also from ends to centre, as in Fig. 15, with an escape behind the centre, a much better lift would be obtained without increasing the drift. This shape is, in fact, that of the gull's wing, and more or less of all soaring birds.

A model in this shape involved the difficulty of making a wing with a double curve, a difficulty which, so far, has rather defeated me. I have, however, made several models, some of which have, when new, flown fairly well. The first one I made bore out the theory, but a second, with the wings pointing forward less than the first, that is, one in which the two



wings were more nearly in a straight line transversely, did better, and I got my best results when I no longer made the wings point forward at all. This model rocked very rapidly and violently until I had cut the little V out of the back. After doing so I got from it the best flights I have ever had. It often flew from my hand till it struck the window at the opposite end of a 21-ft. room with a total fall of 3 or 4 feet.

Its flight commenced with a swoop downwards at a considerable angle, so that I estimated its angle of fall for the last 15 feet as sometimes no more than one in ten. This model was only 7 ins. across the wings.

These gliders were difficult to balance. When they flew well and straight indoors they did as well out of doors in a light breeze. When the breeze is strong there is generally a downward trend over the greater part of my garden. It is a small garden with two high

trees in front of the house, the branches of which deflect the wind downwards. I have confirmed the fact of this general downward trend by watching the movements of tobacco smoke over different parts of the garden.

Indoors, these models with double-curved wings often flew straight from my hand, and swooped till they had, so to speak, "got into their stride," when, without apparent cause, they suddenly upset, or sometimes only partially turned over, and commenced a new swoop in a new direction. The upset was usually to the same side time after time, and often I could only make them fly decently by bending the wings till they were so unsymmetrical that they ought to have upset at once.

I found out at last, in one model, that one of the wings was a little weak at its junction with the body, and that when both wings appeared to the eye to be quite symmetrical, a slight pressure under the wings would cause one of them to "set back" slightly, and it was this setting back of one wing when under full pressure that caused the sudden upset in the middle of a steady flight.

These double-curved wings were never so stiff as the cylindrical ones, and their falls and collisions with furniture, etc., tended to bend down the outer front corners of the wings, so that in flight the wing ends probably tried to plunge or pitch forward, and, not being prevented by the tail until they had reached the limit of their flexibility, brought about a condition of things in which the wing-tips had a negative angle and the centre had a positive angle—a condition of things the opposite of that which obtains with the birds. If the flexibility of the two wings was not exactly the same—and I don't suppose it ever was—one wing would turn down more than the other and bring about a rapid revolution on a fore and aft axis—as usually happened.

This only took place when the wings were under full pressure.

I tried to add an upward curve to the whole back edge of the wings, as in the S section glider, but with a double curve to negotiate it was not easy. I failed to get any really good flights with such an arrangement, either in steadiness or angle of fall, but it certainly eliminated the sudden upset in the middle of a steady flight, and so tended to confirm my diagnosis of the cause of such upset, and of the steadiness of the long, narrow, and weak glider with the S section, which broke after its first and only glide out of doors.

In trying different kinds of tails attached only at the centre with the double-curved wings with the central opening behind, I got the best results from a tail, whose spread and length were equal to one another, and a little greater than the width, fore and aft, of the wings. The downward air-stream came chiefly from where the back edges were cut away in the centre, so the tail did best when concentrated there.

I find that my rather timid suggestion, in my last paper, of using a partially adjustable

Fig 16

front rudder, to be operated by the aëronaut during flight (and which was so timid owing to my belief that it was quite new, and would be considered dangerous by all practical gliders), had already been left behind by the Messrs. Wright before I had thought of it. Now, finding a movable front horizontal rudder has been proved successful in a full-sized man-carrying machine, I am altogether an advocate

of making adjustments of balance depend entirely on the skill of the aëronaut in using such a rudder—but I would still have a horizontal fixed tail.

In order to control the tendency of a curved wing to pitch forward, however deep the curvature, I found that all that was necessary was to increase the angle at which the tail was turned up. With very deep curvature of the profile, and no front horizontal rudder, the tail had to be so sharply turned up that it added greatly to the resistance of the glider, and in fact acted as a drag as well as a true tail. The addition of the horizontal rudder in front permitted the tail to be turned less sharply up, and so gave a better angle of fall when once the whole glider was properly adjusted; but it also gave another item that might, from want of proper adjustment, prevent steady flight.

The same thing might be rather differently expressed by saying that for longitudinal stability a longitudinal dihedral angle is necessary.

Fig. 16 (1) shows the general shape to be followed, and (2), (3), (4), and (5) the different ways of following it.

The front rudder, while adding to the drift, adds at the same time a little to the lift, while the upturned tail decreases the lift while adding to the drift. A front rudder should, therefore, give the best angle of fall, but in practice the turned-up tail always gave the steadiest flight. I have once persuaded a glider to sail fairly well with a front rudder only, but I failed to repeat it. With a tail added that was so slightly turned up as to add little to the drift, and to be alone insufficient to prevent pitching, a front rudder acted well.

With wings of the "cylindrical" pattern—that is, straight transversely but curved fore and aft—a flap at the rear edge, turned slightly up, would, with the addition of a front rudder, be all that would be required to ensure longitudinal stability. This would be like my S section, with the rear curve much diminished, but with its full stability preserved by the audition of a front rudder.

With my double-curved wings I did not get quite such deep curvature in a fore and aft direction as in my cylindrical-shaped wings. The endeavour to get a curvature from root to tip tended to straighten out the fore and aft section, hence probably the comparative weakness and flexibility of these wings in my models.

A deep fore and aft curvature in small paper wings gives great rigidity, and in large wings would give room for a greater strength of construction with less resistance to advance from exposed struts and stays than would be the case with a slighter curvature, but a slight curvature gives a much better angle of fall than a deep curvature. The lifting power of wings has to be considered in terms of screw-thrust; that is, in comparison to their total drift and head resistance, in order to estimate the angle of fall. A deeply-curved wing would, therefore, be bad except for the possibility it offers of strong construction without so much exposed framework as would be necessary in a wing of less curvature, and which would detract from the good qualities of such a wing. The best wing profile will be a compromise, decided by considerations of construction and strength of materials.

My experiments suggest that the greater part of the lift of a curved wing is due to a slight compression of the air under the wing, which is caused by the inertia of the air particles in contact with the wing, and that of the underlying strata of undisturbed air. Vide Fig. 22.

The air passing over the wing is thrown up by the leading portion, and creates a slight rarefaction over the rear portion, and this is possibly all that gives a curved wing its tendency to pitch forward. A wing-profile which I tried, which had the highest point at about a

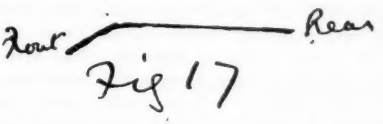


Fig 17

quarter of its breadth from the front edge, and the back three-quarters of which was a straight line, vide Fig. 17, gave less lift, but also had a less inclination to pitch. The centre of gravity in this case had to be placed further forward than in the case of a wing curved to the arc of a circle.

I presume that in this case the compression of the air did not extend so far back as if the curvature had been continuous up to the back edge, as air could escape more easily from under the flat part.

The air passing over the top of such a profile would create the same pressure on the front part—but owing to its greater steepness the pressure would act more as drift and less as downward pressure than in the circular profile—but after forming a slight rarefaction behind the highest point would probably have nearly reached its normal pressure again before leaving the back edge, and thus there would be much less tendency to pitch.

When the wind is blowing over a hill (vide

Fig. 18), I have seen birds soaring all over the windward side, and above the crest, and also, at a greater altitude, even behind the crest. From watching the movements of the gulls following a ship, and from the phenomenon shown in Fig. 18, I have always supposed the crest of the wave of wind passing over any obstacle to be a little beyond the highest point of that which caused the wave. These con-

Fig 18

Fig 19

siderations lead me to suppose that wind blowing over a convex surface follows some such path as that shown in Fig. 19. (The arrows are so drawn as to exaggerate the behaviour of the air current.) This would cause compression in front and rarefaction behind, and if the profile was curved like the arc of a circle, the lift behind would not greatly exceed the

Fig 20

depression and the total effect, though contributing a little to the lift, would tend chiefly to upset the wing. With a steeper slope in front and a longer one behind, as in a parabolic profile (Fig. 20), even though there might still be the same proportion of power between the pressure in front and the rarefaction behind, the pressure in front would have less surface to act on, and its effect would be more felt as resistance and less as depression, while the rarefaction behind would act more as lift and less as drift, and would also act over a larger portion of the surface. The continuous curvature of the back part of the wing would produce a greater area of rarefaction than if the profile ended (as in Fig. 17) in a straight line. This form might then be theoretically considered the best for the upper surface of a wing, giving fair stability and a good lifting power without unduly increasing the drift.

The air passing under a concave surface appears, from experiments carried out by Phillips, Hargrave, and Merrill, and, perhaps, others, to have a tendency when the curvature of the surface is sufficiently pronounced, to turn over, like a breaking wave, and form a vortex, as in Fig. 21. It does not take much to cause an air current to do this, and even when it has most the effect of a steady stream, we should probably find, if we could follow its course, that it was full of swirls and eddies.

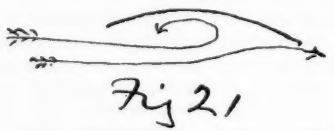


Fig 21

I once blew tobacco smoke across a thin sheet of sunlight, coming through a straight crack in the door of a mountain hut in Switzerland, and so obtained a section of the air currents, and it showed a most intricate pattern of whirls and curls.

The air passing under the front edge would probably cause a slight rarefaction immediately behind it, and that rarefaction might be maintained owing to the inertia of the particles of the compressed part beyond, but there would undoubtedly be a compressed part beyond, and the more the back part of the wing curved down, the nearer to the back edge of the wing would the area of compression reach; but at the same time the drift would be increased owing to the pressure everywhere acting in a direction normal to the surface of the wing. The rarefaction and compression would be the same under the wing if we consider the currents to follow the surface instead of forming eddies —and in a wing of slight curvature we should probably get a truer idea of their action by

considering them as doing so. The inertia of the air particles would cause the air currents not to change its direction until it had got a little beyond the obstacle which caused the change, as is the case with the wind passing over a hill. Vide Fig. 22.

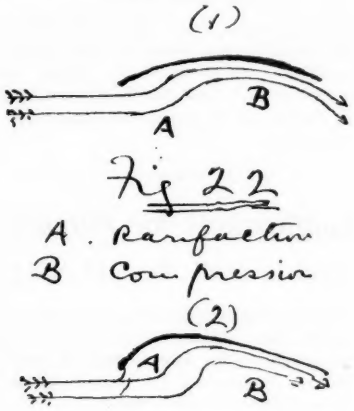


Fig 22

The steeper the front portion of the wing-curve the greater would be the rarefaction behind it, thus diminishing the lift, and adding to the drift.

This consideration suggests that the arc of a circle would be a better form of curvature for the under surface of a wing than a parabolic profile.

When once the compression had commenced, the constantly and evenly curving surface would keep up the compression to a point as close to the back edge as the decreasing inertia of the underlying strata would allow.

Evidently when the curvature of the wing is sufficient to bring about the partial rarefaction above the wing and compression below it, any further increase in the height of arc would add

Fig 23

to the drift in greater proportion than to the lift, so that a deep curvature, while adding to the total lift at a given speed, would decrease it when considered in terms of drift.

These considerations lead to a wing section parabolic above and circular below, as in Fig. 23, and is not this very like the curvature that the bird's wing has?

Close to the body the downward curvature of the under surface of the wing in front may be sharper, as in Fig. 24, as it is supplied with compressed air from the more distant parts of the forward-pointing wing.

Fig 24

The sections shown in Figs. 23 and 24 would allow of a good many structural complications being completely enclosed within the wing, thus adding greatly to its strength, and so permitting a considerable diminution of the exposed struts and stays, which add so much to the head resistance of gliding machines.

Messrs. Groombridge and South's Exhibition of Aëronautical Apparatus.

This exhibition, which was held at 69, Regent Street from April 27th to May 2nd, 1903, was of a private character, and dealt with the aëronautical inventions of Mr. Charles Groombridge.

The following is a description of the various exhibits:

1. Model of a proposed aërial navigator, constructed upon a scale of one inch to a foot; the full size machine being about 80 feet in length by 60 feet in breadth. The general principle of construction is an arrangement of superposed aëroplanes, both in front and in rear of the propellers, with a larger one surmounting the whole machine. The propellers (six in number) are adjusted three on each side of the framework body of the machine, each pair being driven by a 20-horse power internal combustion engine. The total proposed force being 60-horse power. The machine is fitted with four ground wheels.

2. Model of Mr. Groombridge's new propeller for aëronautical purposes, mounted upon a stand and capable of being worked by hand, so as to show the action of the vanes. The general construction of the new propeller consists of a main or driven central shaft, which forms an axis within a rectangle, the two vertical sides of which form

the axes carrying the vanes. In the driving stroke the vanes extend outwards, beyond the rectangle, while they return edgewise or feathered within it. During the propelling stroke, the vanes become strained backwards, against the resistance of springs, and as the vanes yield to the air, the air remains practically unmoved, and thus becomes an inert or solid fulcrum against which the vanes press. As the vanes come into action they assume a vertical position, while at the completion of the stroke they automatically feather. The propelling stroke is effected upon a long or extending radius, the feathering upon a shorter one. The main central shaft carries opposite to each other two sets of vanes, so that one set is propelling, while the other is feathered, propulsion being continuous.

3. One half of the new propeller constructed with three vanes of large size, which would be suitable for use in a full-size machine. This was constructed by Mr. Patrick Y. Alexander, and at his expense, at Batheaston, and kindly presented by him to Mr. Groombridge.

4. A small vane of the new propeller fitted in bearings with a convenient handle, to enable the visitors to test by hand the great resistance offered by the air to the vane when in action.

5. Three vanes of the new propeller of a larger size fitted in bearings with convenient handle for same purpose as the preceeding.

6. Model of new method of steering. A feature in this method of steering, is the rapidity and ease with which the guiding vane can be changed from a passive to an active state. In a passive state its unobtrusiveness is very apparent, as when the machine is resting upon the ground the wind from any direction would have but a minimum effect upon it, while in the active position it causes the machine to feel its guiding influence in any desired direction; it can also be so adjusted as to utilize the force of the wind blowing at any angle.

7. Model of another new propeller, based upon the same principle as described in No. 2, that is, the straining of the vane backwards against the resistance of a spring; but in which the vanes are differently constructed, adjusted, feathered, and worked by very different mechanism.

8. Two vanes of this proposed new propeller mounted in a frame so that they can be conveniently worked by hand, their action explained, and the backward straining of the vanes by the air demonstrated by the operator.

Applications for Patents.

(*Made in April, May, and June.*)

The following list of Applications for Patents connected with Aëronautics has been specially Compiled for the AËRONAUTICAL JOURNAL by Messrs. BROMHEAD & Co., Patent Agents, 33 Cannon Street, London, E.C.

7763. April 3. DAVID HAYLOCK AND RICHARD ARTHUR HAYLOCK. **Self-lifting Flying Machine (without a Balloon).**

7969. April 6. ANTON WECZERA AND LEWIS WELLS BROADWELL. **Improvements in Flying Machines.**

8148. April 8. HERMANN HARTIG. **Device to be used for Flying Exercises.**

8595. April 15. SAMUEL FRANKLIN CODY. **Improvements in and connected with Kite Flying, and Apparatus employed therewith.**

8604. April 15. HORATIO FREDERICK PHILLIPS. **Improvements in or relating to Flying Machines.**

10990. May 14. RICHARD WHITTINGHAM. **An Improved Air-car or Flying Machine.**

12149. May 28. HENRY SHEPLEY BOOTH. **Improvements in Aerial Machines.**

13075. June 11. GEORGE CLOUT. **A Mechanical Air-Ship.**

Owing to pressure on space, the "Notes," "Foreign Periodicals," and "Notable Articles" are reserved for the next issue.